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(54) Flow measuring apparatus

(57) To measure very low flow rates fluid is stored and passed periodically through a flow meter (4). A storage chamber (9) of variable volume includes a movable wall (11) and closes a stop valve (10) when in position (A) and opens it when in position (B). The wall (11) also moves a throttling valve (23) whereby stored fluid is discharged relatively slowly to reduce effects of starting and stopping the meter. However when higher flows occur the wall moves to position (C) and moves the throttle valve (23) from the flow path. The throttle and stop valves may be combined.

Fig. 1

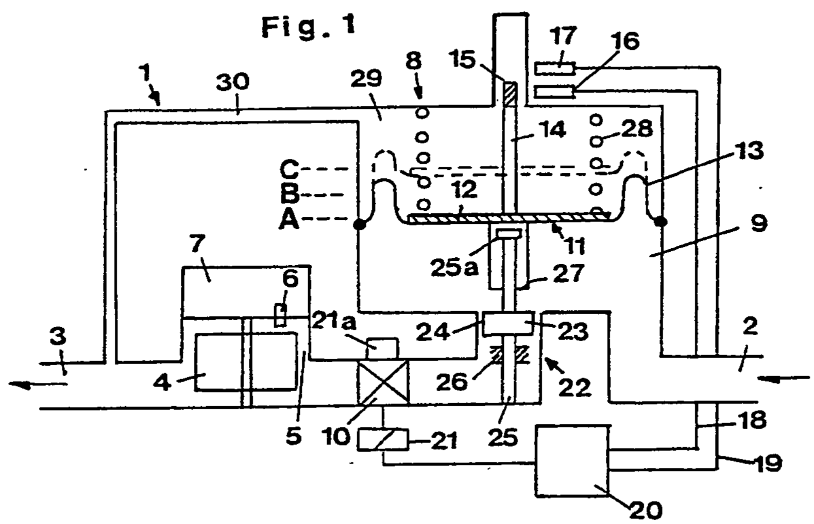


Fig. 1

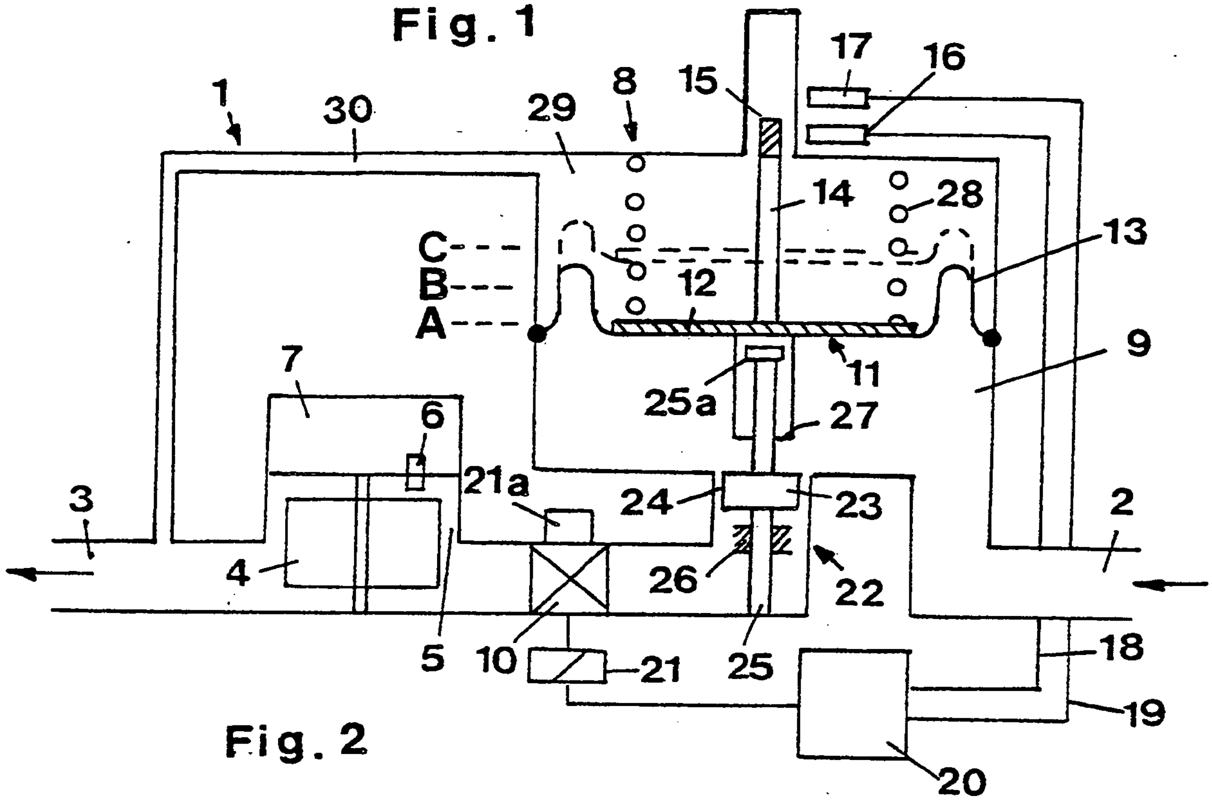


Fig. 2

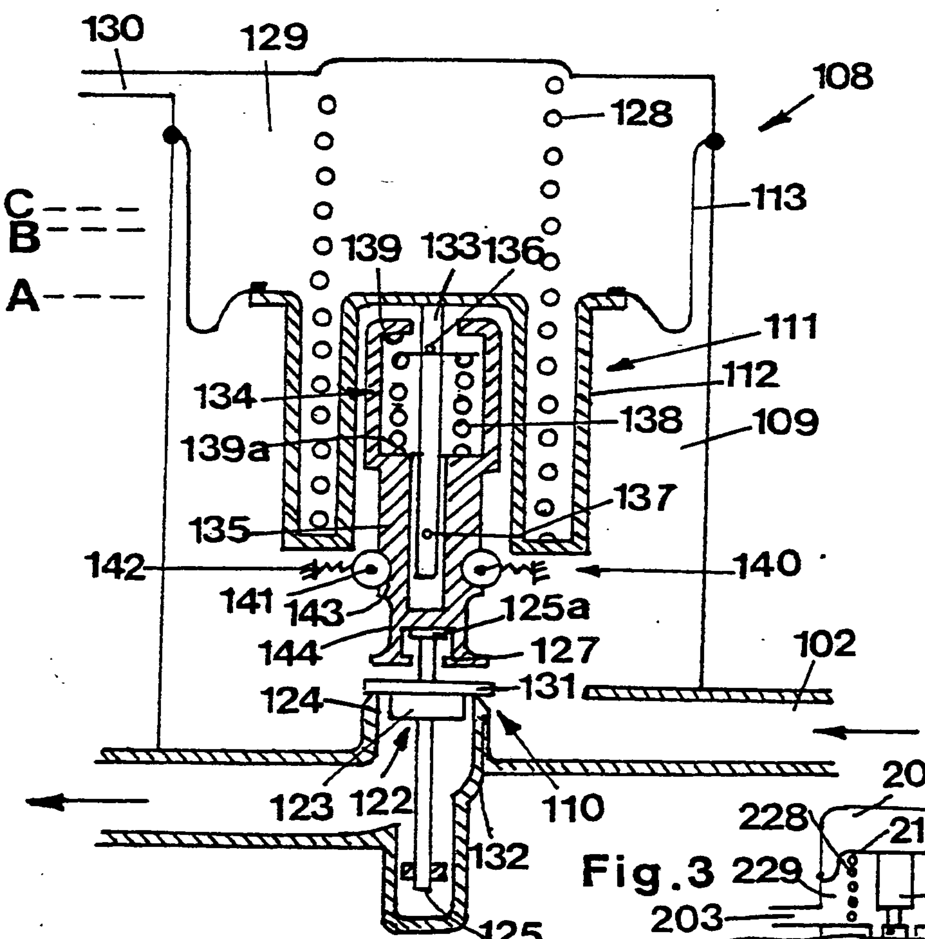
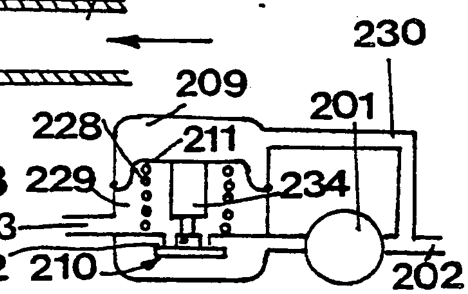


Fig. 3



SPECIFICATION

Flow measuring apparatus

This invention relates to flow measuring apparatus comprising a flow meter, such as an impeller meter, and auxiliary equipment for increasing the measuring accuracy at the lower flow rate end of the measuring range.

It is known that flow meters such as impeller meters scan without contact and produce very accurate results over the greater part of the measuring range but that in the case of small flow quantities per unit time (flow rates) one must accept mistakes in the measurement. At very low flow speeds, the flow meter will not respond at all. This can present difficulties if the flow measurement is for the purpose of producing consumer accounts, for example if it is necessary to calculate the consumption of hot water or amounts of heat depending on the hot water in the case of remote heating installations.

For this reason, numerous kinds of auxiliary equipment have become known for increasing the measuring accuracy in the lower measuring range. Thus, by producing oscillations, one can reduce the bearing friction of a rotor of the flow measuring device (DE-OS 31 24 683). By constructing the measuring chamber, excessive increase in the error curve can be suppressed (DE-PS 846 624). An impeller wheel can be impinged by a nozzle jet and given a higher speed (DE-OS 26 16 323). In all cases, however, it is only possible to reduce the measuring error in the lower part of the measuring range; it is not possible to avoid the fact that at very low flow speeds the rotor of the flow meter fails to respond altogether.

Further, a flow measuring device is known (DE-OS 26 21 278), for measuring pulsating flow quantities such as those delivered by a fuel diaphragm pump in a motor vehicle. The inlet of the flow meter is connected to a storage chamber of variable volume bounded by a movable wall in the form of a spring-loaded diaphragm. The opposite diaphragm surface bounds a pressure chamber which communicates with the outlet of the flow meter. By means of the storage chamber one can smooth out the pulsations so that the flow meter will detect the mean flow quantity.

The present invention is based on the problem of providing a flow measuring apparatus of the aforementioned kind in which one can not only reduce the errors in the lower measuring range but also detect very low flow quantities.

This problem is solved according to the invention in that the auxiliary equipment comprises:

a) a storage chamber of variable volume bounded by a movable wall, the side of the movable wall remote from the storage chamber bounding a pressure chamber and being connected to the side of the flow meter remote from the storage chamber, and

b) a stop valve which is in series with the flow meter downstream thereof and opens when the movable wall during outward motion reaches a first position corresponding to a larger storage volume and closes when the movable wall during inward motion reaches a second position corresponding to a smaller storage volume.

If in this construction very small flow quantities are encountered, the stop valve is closed. The fluid therefore accumulates in the storage chamber until the movable wall reaches the first position. The stop valve is then opened and the storage chamber contents are led through the flow meter in one go. As soon as the movable wall reaches the second position, the stop valve closes again. In this manner of operation, the measurement of flow is without problem, because the fluid flows through the measuring chamber of the flow meter at an adequately high speed. The stop valve may be disposed in front of or behind the flow meter.

In a preferred example, a throttling member downstream of the storage chamber is likewise in series with the flow meter and with the stop valve and is variable from a larger throttling resistance to a lower throttling resistance when the movable wall is displaced beyond the first position. The throttling member ensures that, after the stop valve is opened, delivery of the storage chamber contents is extended over a certain period so that the starting and stopping conditions in the flow meter are negligible. However, as soon as a larger flow is to be measured, the throttling member is automatically made ineffective so that normal measurement is not impeded.

It is favourable if the stop valve has a constant closing motion. Since the closing motion takes a certain time, problems can be avoided that would arise on sudden closing by reason of subsequent motion of the flow meter. Such a closing motion can for example be achieved with the aid of a damping apparatus. The stop valve can also be in the form of a diaphragm, somewhat like in a photographic apparatus, which closes slowly.

Desirably, the throttling member is disposed between the storage chamber and the stop valve. In this way, the throttling member can be operated from the movable wall without the need for seals.

It is of advantage if the movable wall is biassed in the inward direction by a force. This force can be produced by a spring, elastic material, weights, a float and the like. It permits the storage chamber contents to be fed through the flow meter at a predetermined speed after opening of the stop valve.

With particular advantage, the side of the movable wall remote from the storage chamber bounds a pressure chamber which is connected to the side of the flow meter remote from the storage chamber. In this way, the predetermined force only has to act against the pressure drop at the flow meter after the stop valve is opened, so that correspondingly small forces will suffice.

In particular, the movable wall comprises a roller diaphragm. This permits a comparatively long stroke so that a correspondingly large change in volume of the storage chamber and comparatively large spacings between the first and second position of the movable wall are possible. However, other forms for the movable wall may be pistons sealingly guided in a cylinder, metal bellows, clamped diaphragms and

the like.

The stop valve may in particular be a magnetic valve. In this case, an activator should be connected to the movable wall which excites stationary sensors associated with the first and second position. The activator is, for example, a magnet and the stationary sensors are formed by reed switches.

A purely mechanical construction is arrived at in that the closing member of the stop valve is adjustable by a servo-element which can be held in a closed and an opened position by a stopping device and which is connected to the movable wall by a lost motion coupling by means of which the servo-element is movable out of the closed position to the open position and vice versa at the respective end of the lost motion. The combination of the stopping device and the lost motion coupling permits the stop valve to be held open during movement of the movable wall from to first to the second position and closed during movement from the second to the first position.

To form the stopping device, depressions may be formed at the servo-element in which resiliently mounted locking members engage. Only when the servo-element is displaced with an adequately large force will the locking members be pressed out of the depressions against the force of the associated springs.

The lost motion coupling may comprise two entrainment members which are connected to the movable wall and, with the interpositioning of a spring, act on two counterbearing surfaces at the servo-element that act in opposite directions. Such a lost motion coupling operates securely and with little noise.

In a preferred embodiment, the adjustable throttling element of the throttling member has a predetermined rest position corresponding to the value of the larger throttling resistance and is connected to the movable wall by way of an entrainment member which carries the throttling element with it to an operating position corresponding to the value of the smaller throttling resistance when the movable wall is disposed beyond the first position. All the connecting elements may be arranged in the storage chamber so that no seals are necessary.

The entrainment member may be formed directly on the movable wall or on the servo-element.

With particular advantage, the throttling element is a filling member which partially fills an outlet aperture of the storage chamber in the rest position and is retracted from the outlet aperture in the operating position. This results in a large pressure drop at large flow.

In a further development, the valve seat of the stop valve may be provided at the outlet aperture of the storage chamber and the closing member may be in the form of a valve plate and the throttling member as a filling member connected thereto. The throttling member and stop valve therefore form one structural unit.

The present invention also provides flow measuring apparatus comprising a flow meter and auxiliary equipment, the auxiliary equipment comprising:

a) a storage chamber of variable volume and bounded, in part, by one side of a movable wall, the other side of the movable wall bounding, in part, a pressure chamber connected to the upstream side of the flow meter, and

b) a check valve which is in series with the flow meter, which opens when the movable wall is moving in a direction to increase the volume of the storage chamber and assumes a first position and which closes when the movable wall is moving in the opposite direction and away from the first position and assumes a second position.

Three forms of flow measuring apparatus according to the invention will now be described, by way of example, with reference to the accompanying drawing, wherein:-

Figure 1 is a diagrammatic representation of a first apparatus;

Figure 2 is a diagrammatic representation of a second apparatus, and

Figure 3 is a diagrammatic representation of a detail of a third apparatus.

Referring to the accompanying drawing, the flow measuring device 1 shown in Figure 1 comprises a supply connection 2 and an outlet connection 3. Between them there is a flow meter 4 in the form of an impeller which is arranged in a measuring chamber 5 and, by way of scanning without contact with the aid of an optical sensor 6, delivers pulses to a counter 7 of which the counting condition corresponds to the amount of flow that has passed up to this instant.

The flow measuring device 1 is preceded by auxiliary equipment 8 comprising a storage space 9 and a downstream electromagnetic stop valve 10. The storage chamber 9 has a movable wall 11 which is formed by a rigid plate 12 and a roller diaphragm 13. An activator 15, e.g. a permanent magnet, is connected to the plate by way of a rod 14. The activator can excite two superposed sensors 16 and 17, e.g. reed switches. The latter communicate by way of lines 18 and 19 with a switching device 20 which, in turn, can excite an electromagnet 21 of the electromagnetic stop valve 10. The latter is provided with a known hydraulic damping apparatus 21a which retards the closing motion.

A throttling member 22 comprises a throttling element 23 in the form of a filling member arranged in the outlet aperture of the storage chamber 9. The filling member is provided with a rod 25 which is guided in a bearing 26 and carries at the upper end a head 25a which can be carried along by an entrainment member 27 connected to the movable wall 11.

The letters A, B, and C indicate three positions of the movable wall 11. In position A, the sensor 16 is excited, in position B the sensor 17 is excited and in position C the entrainment member 27 engages the head 25a.

The movable wall 11 is subjected to a spring 28. On the side opposite to the storage chamber 9 there is a pressure chamber 29 connected to the outlet connection 3 by a conduit 30.

This flow measuring device operates as follows: In the rest condition, the stop valve 10 is closed. If now, a very small amount of fluid arrives through the inlet connection 2, the stop valve 10 remains closed.

However, the storage chamber 9 enlarges because the movable wall 11 is displaced upwardly against the force of spring 28. As soon as the position B has been reached and the sensor 17 responds, the stop valve opens and the stored amount of fluid is pushed under the influence of the spring 28 out of the storage chamber 9 through the flow meter 4 and to the outlet connection 3. The throttling member 22 brings about such throttling that the speed of flow suffices to let the flow meter 4 operate satisfactorily but on the other hand the measuring period has to be so long that the starting and stopping conditions have no marked influence on the measuring result. When the movable wall 11 has reached the position A again and the sensor 16 responds, the stop valve 10 is closed so slowly that the stopping movement of the impeller flow meter 4 is not influenced. This cycle can be repeated several times.

In contrast, when there is a larger flow, the movable wall 11 is pushed beyond the position B up to the position C and therebeyond. Since this makes the entrainment 27 effective, the throttling element 23 is lifted out of the outlet aperture 24 so that the throttling effect disappears. With such flow quantities, the flow meter 4 operates normally and with little or no marked error.

The amount of fluid to be stored depends on the particular conditions and the nature of the flow meter. In an impeller meter of the vane type, it is sufficient to enable about 4% of the maximum flow quantity per unit time to be stored. In one example, therefore, the change in volume of the storage chamber 9 amounted to 0.2 litre whilst the flow meter operated normally, that is to say with a continuous throughflow, in the measuring range of 40 litre/hour to 1000 litre/hour.

In the Figure 2 arrangement, the stop valve 110 is not controlled electromagnetically but mechanically. Corresponding integers have reference numerals increased by 100 in relation to Figure 1. A closing member 131 of the stop valve 110 co-operates with a valve seat 132 which surrounds the outlet aperture 124. This closing member is made in one piece with the throttling element 123 which is arranged in the outlet aperture 124.

In the movable wall 111, the plate 12 is replaced by a moulded member 112 having an annular receiving space for the spring 128. The moulded member 112 carries a rod 133 connected to a servo-element 135 by way of a lost motion coupling 134. The lost motion coupling comprises two pins 136 and 137 on the rod 133 which are in the form of entrainment members and each of which can act on a respective one of the two ends of a spring 138 and oppositely directed counterbearing surfaces 139 and 139a on the servo-element 135 that are adapted to co-operate with the respective other end of the spring 138. A locking apparatus 140 comprises two roller-like locking members 141, each axle of which is loaded by a compression spring 142 and can selectively engage in a depression 143 or in a depression 144 therebelow on the servo-element 135.

In this flow measuring device, the operation is as follows. In the rest condition, the stop valve 110 is closed. If a small amount of flow arrives, the stop valve remains close. However, the movable wall 111 is moved upwardly. The servo-element 135 is retained in the closed position by the locking apparatus 140. It is only when the entrainment member 137 reaches the spring 138 in position B that the servo-element 135 is taken along upwardly, whereby the locking members 141 are transferred from the depression 143 to the depression 144. This causes the head 125a of the rod 125 to be lifted slightly by the entrainment member 127 on the servo-element 135, so that the stop valve 110 is opened but the throttling element 122 still retains the condition where there is a large throttling resistance. Consequently, by means of the spring 128 the stored fluid can be discharged through the flow meter to the outlet. As soon as the position A has been reached again, in which the entrainment member 136 acts on the spring 138 from above, the servo-element 135 is displaced downwardly and the stop valve 110 is closed again. This cycle can be repeated several times.

If there is a larger amount of flow, the movable wall 111 is displaced upwardly beyond the position B, whereby the rod 125 and thus the throttling member 123 are pulled upwardly until it is finally lifted completely out of the outlet aperture 124 in the position C. The amount of flow can now reach the flow meter without throttling.

In the arrangement of Figure 3, where corresponding parts have reference numerals increased by 200, the storage chamber 209 is connected to the inlet connection 202 by way of a branch conduit 230 whilst the outlet connection 203 branches off from the pressure chamber 229. The stop valve 210 and throttling valve 222 are combined as in Figure 2. The components such as the lost motion coupling and the like disposed between the closing member of the stop valve 210 and the movable wall 211 are constructed similarly to Figure 2. The movable wall may also be formed by a sealed piston or metallic bellows.

The flow measuring devices described and illustrated are particularly suitable for remote heating installations in which the consumption of water or the consumption of thermal energy has to be determined accurately over prolonged periods.

CLAIMS

1. Flow measuring apparatus comprising a flow meter and auxiliary equipment, the auxiliary equipment comprising:

a) a storage chamber of variable volume and bounded, in part, by one side of a movable wall, the other side of the movable wall bounding, in part, a pressure chamber connected to the upstream side of the flow meter, and

b) a valve which is in series with the flow meter, which opens when the movable wall is moving in a direction to increase the volume of the storage chamber and assumes a first position and which closes when the movable wall is moving in the opposite direction and away from the first position and assumes a second position.

2. Flow measuring apparatus as claimed in Claim

1, wherein a variable throttle is provided downstream of the storage chamber and in series with the flow meter and the valve, the throttle providing a variable resistance ranging from a relatively large value when the movable wall is in its first position, to a smaller value as the wall moves in the first mentioned direction and away from the first position.

3. Flow measuring apparatus as claimed in Claim 1 or Claim 2, wherein the valve has a constant closing rate.

4. Flow measuring apparatus as claimed in Claim 2 or Claim 3, wherein the throttle member is disposed between the storage chamber and the valve.

5. Flow measuring apparatus as claimed in any one of Claims 1 to 4, wherein the movable wall is biassed by force-applying means, for movement in the said opposite direction.

6. Flow measuring apparatus as claimed in any one of Claims 1 to 5, wherein the movable wall comprises a roller diaphragm.

7. Flow measuring apparatus as claimed in any one of Claims 1 to 6, wherein the valve is an electro-magnetic valve and an activator is connected to the movable wall to excite stationary sensors associated, respectively, with the first and second positions.

8. Flow measuring apparatus as claimed in Claim 7, wherein the sensors are operable without contact.

9. Flow measuring apparatus as claimed in any one of Claims 1 to 6, wherein a closure member of the valve is displaceable by a servo-element which can be arrested in positions corresponding to a closed and an open position of the closure member by means of a stop device and which is connected to the movable wall by way of a lost-motion coupling for releasing the servo-element from either of its arrested positions.

10. Flow measuring apparatus as claimed in Claim 9, wherein the stop device comprises depressions in the servo-element and resiliently mounted stops for engaging in those depressions.

11. Flow measuring apparatus as claimed in Claim 9 or Claim 10, wherein the lost-motion coupling comprises two entrainment members which are fixed relative to the movable wall and which, with an interpositioned spring, act on two oppositely facing bearing surfaces of the servo-element.

12. Flow measuring apparatus as claimed in Claim 2 or any one of Claims 3 to 11 when appendant to Claim 2, wherein the adjustable throttle has a movable throttling element connected to the movable wall by way of an entrainment member, the entrainment member being arranged to move the throttling element to an operating position corresponding to the smaller value of throttling resistance when the movable wall is moved from the first position to increase the storage volume.

13. Flow measuring apparatus as claimed in Claim 12 when appendant to Claim 9, wherein the entrainment member for connecting the throttle element and the movable wall, is formed on the servo-element.

14. Flow measuring apparatus as claimed in Claim 12 or Claim 13, wherein the throttling element is a plug-like member which, when the apparatus is non-operative partially fills an outlet aperture of the storage chamber and which is retracted, to a varying degree, from that aperture during operation of the apparatus.

15. Flow measuring apparatus as claimed in Claim 14 when appendant to Claim 9, wherein a valve seat of the valve is provided at the outlet aperture, the valve closure member is in the form of a valve plate and the throttling element is connected to that plate.

16. Flow measuring apparatus as claimed in any one of Claims 1 to 15, wherein the flow meter is an impeller-type meter.

17. Flow measuring apparatus substantially as hereinbefore described with reference to, and as illustrated by Figure 1 or Figure 2 or Figure 3 of the accompanying drawings.

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